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VibraTip® durability in clinical practice: how long does it last?

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Abstract

VibraTip® is a battery-powered, disposable, key fob-sized source of vibration used to assess the integrity of vibration perception. To find out how long the device lasts, the stability of its vibration output was measured in response to two usage patterns:-

In the first, VibraTip® was subject to 7000 half second activations separated by 2 second rests. This yielded fairly consistent frequency output for the first 6000 activations but an early reduction in amplitude over the first 1000 activations, steadying between 2000 and 6000 activations.

In the second, designed to mimic more closely real life clinical usage, runs of ten, half second activations at 2 second intervals were interspersed by 10 minute rests. The cycle was repeated 350 times in all with additional overnight rests to allow electrochemical recovery. VibraTip® performance under these conditions was highly consistent over at least the first 1500 activations, with very little change in vibration frequency even after 3500 discharges.

These results indicate that usage patterns markedly affect VibraTip® durability. Rests between 'patients' and overnight, characteristic of normal clinical activity, suggests that VibraTip® is likely to provide very consistent performance in the clinical arena for many months of routine use.

Introduction

VibraTip® provides a clean, quiet (< 30 dB), discrete and consistent source of gentle vibration for use by the bedside, in clinic and potentially as an aide memoire in patients' own homes. It was designed to facilitate early detection of neuropathy by overcoming many of the limitations of standard tuning forks and of calibrated vibration sources. Squeezing VibraTip® firmly between thumb and index finger while gently touching the patient's skin twice with the rounded tip of the device, each time for about half a second, explaining that 'this is touch one' and 'this is touch two' while making either, neither or both of the stimuli vibrate before asking the patient to report which vibrated, is rapid and highly reliable. Its ease of use

makes it a quick, simple and reliable diagnostic tool for the expert and non-expert alike¹⁻³

Clinical utility

Table 1

Technical details

VibraTip® is activated by squeezing its casing firmly between finger and thumb. This closes the circuit in the pocket-sized device and allows the battery (or more accurately a non-rechargeable alkaline manganese button cell: LR44 but also AG13, A76 and LR1154) weighing less than 2g to drive a micro-vibrating motor. The button cell has a service capacity of more than 90% charge retention after a year at 20°C, and in addition to impressive resistance to 'running down when not in use', is capable of delivering approximately 145mAh at 1.5 volts when new. The starting current and starting voltage for motor spin-up is approximately 110mA and 1.0 volts respectively.

Longevity

Continual low-rate drain to end-of-discharge voltage (nominally 0.9 volts) typically exceeds 110 hours with a reproducible relationship between voltage and duration of discharge (figure 1; button cell manufacturer's data). In clinical use, however, VibraTip® is not discharged completely in a single activation but is activated in a series of short bursts (half a second is recommended) separated by the time taken for the patient to report the sensation and for the device to be repositioned. Invariably there is a longer rest between patients, and a much longer rest between clinics, all of which very significantly effect electrochemical recovery of the button cell.

If VibraTip® is activated continuously until the button cell appears to be exhausted and the motor stops, resting the device for thirty minutes or more restores some of the button cell's electrochemical potency. When an attempt is made to activate the device once again (i.e. the circuit is closed by holding the button down) the motor

will often run vigorously for a further five or ten minutes. An additional rest restores the button cell once again, but for a shorter time. Thus the question 'how long does VibraTip® last' is as hard to predict as the charge life of a smart phone battery, or a pen torch, if, for example, an attempt is made to define 'routine use' or judge the point at which the light emitted is insufficient to reliably elicit pupillary reflexes. Nevertheless, to try and establish the durability of VibraTip® subject to a typical pattern of clinic use, several studies were undertaken under laboratory conditions.

Methods

1. To quantify VibraTip® battery (button cell) performance, a new VibraTip® was connected to a circuit that sequentially activated the motor for 500ms every 2 seconds (Figure 2A). The voltages at the beginning and end of each of 7000 sequential 500ms activations were recorded (figure 2B).
2. To assess changes in the frequency and amplitude of VibraTip® vibration as the button cell becomes progressively exhausted, the rounded tip of a VibraTip® was secured to an accelerometer and powered by a highly accurate low voltage power supply (Figure 3A). The frequencies (Figure 3B) and amplitudes (Figure 3C) of VibraTip® vibration were recorded using the accelerometer in conjunction with an oscilloscope while driving the micro-vibrating motor with voltages recorded from a button cell as its output declined over 7000 sequential 500mV activations at 500 activation intervals recorded in the first part of the study. In other words VibraTip® was powered to perform as if it had previously delivered up to 7000, half second bursts with 2 second rests between each.
3. In a third experiment, a new VibraTip® button cell was discharged in a more realistic cycle of ten sequential half second discharges separated by 2 seconds, followed by a 10 min rest. The cycle was repeated 350 times during working hours over 5 days, a total of 3500 motor activations and rests, with the cycle running during the day but rested overnight to more closely reproduce the pattern of use seen in clinic (Figure 4).

Results

With the button held down (i.e. A continually closed circuit) VibraTip® runs down to a standstill in approximately 45 minutes (data not shown). Activated in half second bursts at 2 second intervals, the device continued to vibrate after 7000 activations (Figure 3). Up to 6000 activations the frequency of vibration remained within 20% of the initial frequency but the amplitude declined continuously from new to a steady state of about 45% of the initial maximum amplitude between 2000 and 6000 activations, in line with an almost stable voltage (Figure 2), before declining once again.

When VibraTip® was allowed to rest for 10 minutes after each series of ten, half second bursts, and again allowed to rest overnight after 10 hours of use, there was no significant reduction in either frequency or amplitude of vibration over the first 1000 activations (100 cycles of 10 activations with variable rests). Although vibration amplitude gradually fell away to about 65% of the initial amplitude, vibration frequency remained almost unchanged at over 98% of initial frequency after 1000 activation, dropping to 93% of initial frequency after 3500 activations.

Discussion

These data clearly demonstrate that the battery life of VibraTip® depends very much on the way that it is used. Discharged continually at high rate (holding the switch down) exhausts the button cell within an hour. Activated over 6000 times for half a second with 2 second intervals discharges the cell more slowly and it continues to function with reasonable stability to this point. Beyond 6000 activations, below about 0.98v, motor speed and the amplitude of tip displacement significantly decline and although vibration continues, it becomes rather lackluster. If VibraTip® is discharged over a week in a pattern that more closely mimics very heavy clinical use - 10 x half second discharges separated by 2 seconds, followed by a 10 minute rest throughout a 10 hour working day for 5 days, frequency and amplitude are stable for the first 1000 uses, followed by a reduction in amplitude to 74% of maximum after 2500 activations and 65% of maximum amplitude after 3500 activations, with a decline in frequency of only 6% compared to new.

Although an experiment to mimic more precisely the rate of discharge of the VibraTip® button cell in more typical clinical practice would, by its very nature, take months to complete, the progressive improvement in button cell behaviour with increasing duration of open circuit breaks between series of activations suggests that under normal conditions, VibraTip® would provide a very consistent source of vibration to test at least 100 patients, if not considerably more.

However much the amplitude of vibration falls away over time, it does so slowly and consistently from one use to the next, unlike tuning fork vibration that decays to zero in seconds from an arbitrary and variable initial amplitude. If it is assumed that button cell power output is the primary arbiter of vibration sense determination, these data support clinical experience, which is that VibraTip® is powered to deliver many months of routine clinical use without significant degradation of performance.

Key messages

- Many factors influence the utility of vibration sense testing in practice
- VibraTip® provides consistent performance to test at least 100 patients
- VibraTip® will last for many months of routine clinical use.

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